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Investigation of the changes in bran mineral content according to the years and growth conditions in bread wheat genotypes

Bilge Bahar[1,*]

[1]Gumushane University, Faculty of Engineering and Natural Sciences, Department of Food Eng., Gumushane, Turkey

[*]Corresponding Author: bilgebahar74@gmail.com

Abstract

Bran is not only the raw material of animal feed or functional products; it has also become a natural additive used in the other industrial fields. For this reason, in this study, it has been aimed to reveal to what extent the minerals (K, P, S, Mg, Ca, Zn, Fe, Mn, Cu, and Na) are affected by genotypes, growth seasons (years) and growth conditions and their interactions, rather than how much and what kind of minerals the wheat bran contains. For this purpose, in the study, in the growth seasons of 2013-2014 and 2014-2015, five bread wheat genotypes were carried out as three replicated under organic and conventional growth conditions according to the trial design of split plots in random blocks. At the end of the study, all minerals except Cu were affected by at least one of the variation sources; in other words, although it varies according to minerals, wheat bran minerals were significantly affected by wheat genotypes, growth years and growth conditions and their interactions. In addition, with this study, significant correlations were found between some minerals in organic and conventional conditions.

Keywords: Minerals, Nutrition, Organic farming, Wheat bran

Introduction

Wheat grain is composed of three parts as coat (bran), endosperm and embryo (germ). Endosperm is made of aleurone and starchy endosperm. Germ consists of embryonic part and scutellum. Germ occupies the percent of 2.5 to 3.5 of wheat grain and is rich for protein, sugar, fat and ash (Delcour and Hoseney, 2010). Bran is composed of pericarp, testa and aleurone. It contains non-starchy polysaccharide (40%), starch (34%), lignin (5%), and protein (13.5%) (Palmarola-Adrados et al., 2005). Pericarp is rich interms of insoluble diet fiber, ferulic acid, bioactive compunds, and vitamins (Hemery et al., 2007). Aleuron, the outer layer of the endosperm, is included in the bran by milling. However, it is rich in minerals and B vitamins and constitutes 7% of the grain (Antoine et al., 2002). Testa, rich in alkylresorcinol, a phenolic lipid, is located between aleurone and pericarp (Landberg et al., 2008). Wheat bran is considered brown gold by some researchers and its enormous applications and high market value make it very important. Wheat bran is used in many fields of the industry such as fermentation, water retaining ability, complex substrate and nitrogen source in media for enzyme production, metabolite production, bioremediation, health aspects, food and feed additive, etc. (Javed et al., 2012).

It is seen that the wheat bran ingredients used in bakery products are very high. The wheat bran content used in biscuit in the study of El-Sharnouby et al. (2012) can be given as an example which were included crude protein (14.0%), crude fiber (15.4%), ash (4.8%), and carbohydrate (75.0%) and also high mineral contents such as calcium, sodium, potassium, iron, phosphorus, zinc, magnesium, manganese, and copper (76.0, 2.0, 1182, 10.6, 1013, 7.3, 611, 11.5, 1.0 mg kg^{-1}). Similar values are confirmed by USDA (2020). Sudha et al. (2011)

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reported the ash, crude protein and fat content in wheat bran used in making pasta as 5.99, 15.1 and 5.83%, respectively. They stated that the total dietary fiber content of pasta was increased 5.2 times with the participation of 40% wheat bran. Hell et al. (2014) stated that wheat bran consists of 3-8% minerals as dry matter. The oil to be used in fried cereal products will be reduced while the dietary fiber content of the product will be increased by the bran additive (Onipe et al., 2015). Wheat bran usage has been increasing year by year and the amount of product obtained from wheat bran was 52 in 2001; however, this number reached 800 in 2011 (Curti et al., 2013). Wheat bran is rich for mineral contents like iron, zinc, manganese, magnesium and phosphorus as mentioned before, but 80% of phosphorus is kept in the phytate forms of iron, zinc and magnesium, and these forms of the elements decrease their intakes (Anderson et al., 2014). Mineral elements have the vital importance for humans, animals and plants. Indeed, they have important biochemical functions; for examples, Ca and P join the structure of bones and teeth; P also functions in the nucleotid, ATP. Na is the cation, provides fluidity outside the cell while K is a cation, provides intracellular fluidity. Also, Mg, Cu, Fe, Mn, Mo and Zn functions some enzymes; S is in the structure of some aminoacids (Soetan et al., 2010). For these responsibilities of the elements, they have been the subjected to the researhes in foods, feeds, and their organic and conventional additives.

This study aimed to investigate the change of some nutritionally important minerals in bread wheat brans according to years and organic and conventional growth conditions.

Materials and Methods

Material

In the study, five hopeful winter bread wheat lines, which were grown in Siran district of Gumushane province in 2013-2014 and 2014-2015 seasons and whose pedigrees and origins are given below, are used as materials (Table 1). Some physical and chemical properties of the trial soils are also given in Table 2.

Table 1. Numbers, pedigrees and origins of the bread wheat genotypes used in the trial

No	Pedigree	Origin
1	KARL/NIOBRARA//TAM200/KAUZ/3/TAM200/KAUZ	Turkey/CIMMYT/ICARDA
2	PYN*2/CO725052/4/PASTOR/3/KAUZ*2/OPATA//KAUZ	Mexica -Turkey/CIMMYT/ICARDA
3	OK98649/TX95V6608/3/ID#840335//PIN39/PEW	USA-Turkey/CIMMYT/ICARDA
4	ST.ERYHTR 1287-08	Ukraine
5	TX98D1170*2/TTCC365	USA

Table 2. Some physical and chemical properties of the trial soils

Analyze	Saturation (%)	Total salt (%)	pH	$CaC0_3$ (%)	P_2O_5 (kg ha^{-1})	K_20 (kg ha^{-1})	Organic matter (%)
Value	68.0	0.15	7.99	10.66	10.95	1490.1	1.63
Evaluation	clayey	saltless	slightly alkaline	calcareous	poor	sufficient	low

Climatic data for 2013-2014 and 2014-2015 growth seasons were given in Table 3. According to the table, although there were not many differences between the years in terms of average temperature. June, which corresponds to the flowering and grain filling period, was more wet (+ 9.4 mm) and more humid (+ 9.1%) in the second growth season (2014-2015).

Table 3. Climatic data of Gumushane province between 2013-2015 and long years average (1950-2015)

Months	Temperature (°C)			Precipitation (mm)			Relative humidity (%)		
	2013-2014	2014-2015	Long years	2013-2014	2014-2015	Longyears	2013-2014	2014-2015	Longyears
October	12.3	14.4	13.8	28.2	61.4	34.3	53.5	64.6	54.0
November	8.7	7.2	7.0	19.6	51.6	45.2	63.4	64.5	48.7
December	-2.2	6.2	-1.3	31.3	14.2	45.7	65.0	63.0	66.3
January	2.1	0.8	0.0	28.5	55.5	47.8	62.9	62.0	59.9
February	3.3	3.3	4.6	22.1	34.4	33.4	54.3	59.5	54.3
March	8.9	7.3	7.3	45.3	67.4	64.2	55.7	55.9	50.6
April	13.5	9.6	12.0	38.1	46.8	47.2	53.8	57.4	44.6
May	17.1	15.9	16.0	66.7	45.3	95.8	58.5	55.1	50.2
June	20.8	20.5	20.5	31.0	40.4	69.1	51.5	60.6	51.5
July	26.0	24.5	24.1	19.3	2.8	5.8	48.7	48.8	41.4
Mean/Total	11.05	10.97	10.40	330.1	419.8	488.5	56.73	59.14	52.15

Method

The trials were planted in the last week of October during the 2013-2014 and 2014-2015 growth seasons, with three replicates by drill, with 500 seeds per square meter. Each plot was the area of 1.05 m (17.5 cm × 6 rows) × 5 m = 5.25 m^2. Twenty tons of organic farm fertilizer (0.32% N, 0.16% P_2O_5, 0.12% K_2O) and 5 t organic poultry manure (3% pure nitrogen) were used per hectare before sowing time. In the conventional plots, 120 kg of pure nitrogen and 60 kg of P_2O_5 per hectare, half of the nitrogen and all of the phosphorus were given together with 20.20.0 commercial fertilizer and half of the remaining nitrogen with ammonium nitrate (26% N) during the tillering period. During the growth period, the weeds in the plots were removed by hand; no herbicides were used. After the maturation is completed, the plots were harvested by sickles and threshed by the Monomak (MNHR- CD0025-BAH type) laboratory thresher machine.

Element contents (K, P, S, Mg, Ca, Zn, Fe, Mn, Cu, Na) of the bread wheat genotypes which were observed from the organic and conventional cultivation between 2013-2015 years were determined according to EPA 6020 method in flour samples milled in laboratory type roller mill of seeds. Accordingly, 0.5 g of each flour sample was burned with 4 ml of 65% HNO_3 and 6ml of H_2O_2 in the microwave (Milestone Start D) and diluted with 50 mL of ultrapure water. The elemental content of the samples was analyzed by inductively coupled plasma-mass spectrometry (inductively coupled plasma mass spectrometry: ICP-MS; Agilent brand ICP-MS 7700e series) technique. In analyzes, Agilent mix 2a standard was used.

The data were analyzed by JMP (2007) according to the split plot trial design in randomized blocks. The differences between the mean values were determined in the same package program by LSD test, and the relationships between the features examined were also determined in the same package program.

Results and Discussion

F values and coefficient variations related with variance analyzis of bread wheat genotypes in terms of bran mineral content (K, P, S, Mg, Ca, Zn, Fe, Mn, Cu, and Na) were given by Table 4. Also, mean values of these elements for years, growth conditions, genotypes, and interactions were shown by the Tables 5-10.

Potassium (K)

Bran K content of bread wheat genotypes for only the interaction of year×growth condition (Y×GC) showed significantly variations. It is understood that the interaction is due to the fact that K content of bran in organic conditions was in the lower group with 3413 mg kg^{-1} in 2013-2014 growth season and 3634 mg kg^{-1} in the upper group in 2014-2015 growth season (Table 7). Although not statistically significant (Table 4); first year and second year (3472 and 3500 mg kg^{-1}, respectively), organic and conventional growth conditions (3524 and 3448 mg kg^{-1}, respectively) (Table 5) and genotypes (3393 to 3606 mg kg^{-1}) (Table 6) showed minor variations. USDA (2020) has reported the lower values for K content of wheat bran.

Phosphorus (P)

Bran P content of bread wheat genotypes for only the interaction of year×genotype (Y×G) and growth condition×genotype (GC×G) showed significantly variations. When Table 8 is investigated, it will be seen that Y×G interaction is caused by the fact that genotype 4 was in the upper group (with 2198 mg kg^{-1}) in the first year, while it was in the lower group (1962 mg kg^{-1}) in the second year. Also, the GC×G interaction was due to the fact that genotypes 1 and genotype 3 were in different groups in organic and conventional conditions (Table 9). Eventhough statistically non-significant (Table 4); first year and second year (1982 and 1929 mg kg^{-1}, respectively), organic and conventional growth conditions (1967 and 1945 mg kg^{-1}, respectively) (Table 5) and genotypes (1895 to 2080 mg kg^{-1}) showed a slight variation. El-Sharnouby et al. (2012) and USDA (2020) have stated the close results (1013 mg kg^{-1}); but Fardet (2010) and Brouns et al. (2012) have reported much higher values which ranged between 900 to 1500 mg 100g^{-1} bran.

Sulphur (S)

Bran S content of bread wheat genotypes changed significantly except years, Y×GC, and GC×G (Table 4). Thus, conventional conditions (1522 mg kg^{-1}) for S content were higher than organic conditions (1291 mg kg^{-1}) (Table 5). In addition, bran S contents of the genotypes changed between 1275 mg kg^{-1} (genotype 3) and 1511 mg kg^{-1} (genotype 4) (Table 6). Y×G interaction was significantly effective on the bran S content, and this interaction was sourced from genotype 4. Because, genotype 4 was significantly higher S values in the second year (1640 mg kg^{-1}) than the first year (1382 mg kg^{-1}) (Table 8). Also, Y×GC×G interaction was significantly effect on the bran S content (Table 4). Because, genotype 2 under conventional conditions was in the upper statistical group with 1610 mg kg^{-1} in 2013-2014 season while it was in the lower group with 1291 mg kg^{-1} in 2014-2015 season. Also, genotype 3 under organic conditions in 2013-2014 was in upper group with 1329 mg kg^{-1} while it was in lower group with 1018 mg kg^{-1} in 2014-2015 (Table 10).

Magnesium (Mg)

Bran Mg content significantly varied according to the years, genotypes, GC×G, and Y×GC×G (Table 4). For bran Mg content, second year (443.8 mg kg^{-1}) was statistically higher than the first year (441.7 mg kg^{-1}) (Table 5). Genotype 4 had the highest Mg content (457.7 mg kg^{-1}) while the genotype 1 (420.4 mg kg^{-1}) had the lowest Mg content (Table 6). Babu et al. (2018) has reported lower values for Mg content of wheat bran (12 mg 100 g^{-1} bran). Also, Mg content of the genotypes'bran was affected from the interaction of GC×G (Table 4). It is understood that this interaction is originated from genotype 1 and genotype 5. Because, these genotypes were in different statistical groups in different growth conditions (Table 9). Also, the interaction of Y×GC×G affected the bran Mg content (Table 4). As a reason of this trio interaction, genotype 1 under conventional conditions was in upper statistical group in 2013-2014 while it was in lower group in 2014-2015. Another reason of the trio interaction was from genotype 5 which was in a low group under organic conditions in 2013-2014 while it was in the highest group under the same growth conditions in 2014-2015 (Table 10).

Calcium (Ca)

Bran Ca content statistically differed for years, genotypes, GC×G, and Y×GC×G (Table 1). Growth season of 2014-2015 had higher for Ca content (374.1 mg kg^{-1}) than the season of 2013-2014 (354.5 mg kg^{-1}) (Table 5). According to the genotypes, range of Ca content were 349.3 mg kg^{-1} (genotype 4) to 373.2 mg kg^{-1} (genotype 5). The lower value for K content of wheat bran has been stated by USDA (2020). GC×G interaction was arised from genotype 5; because, this genotype was in different statistical groups in different growth conditions (Table 9). Also, genotypes 2 and 5 caused to the interaction of Y×GC×G. Genotype 2 under organic conditions was in the lowest statistical group in 2013-2014 while it was in the higher group in 2014-2015. In addition, genotype 5 which was in a low group under conventional conditions in 2013-2014 while it was in upper group under the same growth conditions in 2014-2015 (Table 10).

Zinc (Zn)

Bran Zn content was significantly different for genotypes, Y×G, and Y×GC×G (Table 4). Thus, the highest values for Zn in the genotypes were found in genotype 1 (40.41 mg kg^{-1}) and genotype 4 (40.41 mg kg^{-1}) while the lowest value was in genotype 3 (38.66 mg kg^{-1}) and genotype 5 (38.36 mg kg^{-1}) (Table 6). Y×G interaction is due to the fact that genotype 3 is in the upper group (with 39.71 mg kg^{-1}) in the first year and in the lower group (37.61 mg kg^{-1}) in the second year (Table 8). Some researchers have reported lower values (El-Sharnouby et al., 2012), while others have stated higher values (Brouns et al., 2012; Babu et al., 2018) for bran Zn. Also, Y×GC×G interaction was from the genotypes 3 and 4. These genotypes under organic growth conditions were at different statistical groups according to the years (Table 10).

Table 4. *F* values and coefficient variations (CV) related with variance analyzis of bread wheat genotypes for bran mineral content

Minerals	CV (%)	F value						
		Years (Y)	Growth Conditions (GC)	Genotypes (G)	Y×GC	Y×G	GC×G	Y×GC×G
K	7.64	1.888	1.215	1.327	7.929**	1.236	1.160	1.167
P	8.84	0.679	0.230	2.236	0.080	2.535*	3.797*	1.234
S	12.82	5.149	24.654**	4.407**	3.833	3.395*	2.314	8.678**
Mg	3.87	9.797*	1.354	7.708**	1.210	1.985	3.227**	3.657**
Ca	4.78	43.855**	0.229	3.275*	0.014	2.445	2.937*	3.800*
Zn	4.39	0.753	0.047	3.866*	0.027	2.565*	2.246	6.228**
Fe	3.43	0.499	6.499*	4.563**	1.106	2.035	4.694**	1.948
Mn	9.25	1.299	0.948	2.654*	0.018	2.373	0.805	0.775
Cu	4.76	0.230	0.071	1.877	0.002	0.947	0.853	1.904
Na	1.02	46.416**	4.218*	3.028*	25.970**	3.643**	9.363**	3.324*

*, ** shows significance level of *F* value at the probability of 0.05 and 0.01, respectively.

Iron (Fe)

Growth conditions, genotypes, and GC×G interaction significantly differed for bran Fe content of bread wheat genotypes (Table 4). In this context, conventional conditions had higher bran Fe content (36.71 mg kg^{-1}) than organic growth conditions (35.89 mg kg^{-1}) (Table 5). Also, the genotypes changed between 35.72 mg kg^{-1} (genotype 1) and 37.60 mg kg^{-1} (genotype 3) for Fe content (Table 6). A wide range for bran Fe content have been presented by some researchers (Fardet, 2010; Brouns et al., 2012). Also, the GC×G interaction results from genotypes 1, 2 and 4 which are in different groups under different growth conditions (Table 9).

Manganese (Mn)

Bran Mn content showed statistical difference for only genotypes (Table 4). Thus, the highest values were from genotype 1 (24.46 mg kg^{-1}) and genotype 3 (24.64 mg kg^{-1}) while the lowest value was from genotype 4 (22.21 mg kg^{-1}) (Table 6). Mn content of wheat bran shows an extensively range like Fe content. So and so, Fardet (2010) and Brouns et al. (2012) reported on these contents which were 0.9 to 10.1 mg 100 g^{-1} bran.

Copper (Cu)

All variation sources did not show statistically significant differences in bran Cu content in bread wheat genotypes (Table 4). But anyway, it has determined that range for Cu content of wheat bran were 4.94 to 5.19 mg kg^{-1} (Table 6). USDA (2020) presents lower value for bran Cu.

Sodium (Na)

Bran Na content of the genotypes significantly varied for all variation sources (Table 4). For years, the second growth season (2014-2015) (5.05 mg kg^{-1}) was higher than the first season (2013-2014) (4.89 mg kg^{-1}) for bran Na content. Conventional conditions also showed higher Na values than organic conditions (Table 5). Na contents of the genotypes ranged 4.94 mg kg^{-1} (genotype 1) to 5.00 mg kg^{-1} (genotype 4) (Table 6). USDA (2020)'s Na values of wheat bran are under this study's findings. Also, Y×GC interaction was statistically significant for bran Na content. Thus, all years and all growth conditions were in different statistical groups as shown in Table 4. In addition, wheat bran Na contents were effected from Y×G interaction; because, all genotypes were in different statistical groups in different growth seasons (Table 8). Interaction of

GC×G resulted from genotypes 1, 2 and 5 showing different Na values according to the growth conditions (Table 8). Bran Na content was also affected from the interaction of Y×GC×G (Table 4, 10).

Table 5. Changes of bran mineral content in bread wheat genotypes according to the years and growth conditions (mg kg^{-1})

Minerals	Years		Growth Conditions	
	2013-2014	2014-2015	Organic	Conventional
K	3472	3500	3524	3448
P	1982	1929	1967	1945
S	1391	1423	1291 b	1522 a
Mg	441.7 b*	443.8 a	440.1	445.3
Ca	354.5 b	374.1 a	365.4	363.2
Zn	39.19	39.73	39.41	39.51
Fe	36.11	36.49	35.89 b	36.71 a
Mn	23.98	23.26	23.35	23.89
Cu	5.05	5.02	5.03	5.04
Na	4.89 b	5.05 a	4.96 b	4.98 a

* Values in each column showed by the same letter are not different according to LSD test at 0.05 of significance level

Table 6. Mean values of the bran mineral content of the bread wheat genotypes (mg kg^{-1})

Minerals	Genotypes				
	1	2	3	4	5
K	3393	3456	3606	3549	3426
P	1965	1935	1895	2080	1905
S	1475 a*	1302 b	1275 b	1511 a	1470 a
Mg	420.4 c	442.9 b	449.3 ab	457.7 a	443.4 b
Ca	369.1 a	364.1 a	366.0 a	349.3 b	373.2 a
Zn	40.41 a	39.38 ab	38.66 b	40.51 a	38.36 b
Fe	35.72 b	36.30 b	37.60 a	36.16 b	35.73 b
Mn	24.46 a	23.85 ab	24.64 a	22.21 b	22.96 ab
Cu	4.94	5.05	5.02	5.19	4.98
Na	4.94 c	4.99 ab	4.96 abc	5.00 a	4.95 bc

* Values in each column showed by the same letter are not different according to LSD test at 5 % of significance level

Table 7. Changes of bran mineral content in bread wheat genotypes according to the interaction of year×growth condition (mg kg^{-1})

Minerals	2013-2014		2014-2015	
	Organic	Conventional	Organic	Conventional
K	3413 b*	3531 ab	3634 a	3365 b
P	1987	1978	1946	1912
S	1229	1552	1353	1493
Mg	436.7	446.7	443.6	443.9
Ca	355.9	353.2	374.9	373.3
Zn	39.18	39.21	39.65	39.82
Fe	35.53	36.69	36.25	36.73
Mn	23.67	24.30	23.03	23.50
Cu	5.04	5.05	5.02	5.03
Na	4.85 d	4.94 c	5.07 a	5.03 b

* Values in each column showed by the same letter are not different according to LSD test at 5 % of significance level

Table 8. Changes of bran mineral content in bread wheat genotypes according to the interaction of year×genotype (mg kg^{-1})

Minerals		**Genotypes**				
		1	**2**	**3**	**4**	**5**
K	**2013-2014**	3427	3570	2522	3481	3360
P		2030 ab*	1982 bc	1803 c	2198 a	1900 bc
S		1387 bc	1376 bc	1363 bc	1382 bc	1445 ab
Mg		428.1	447.2	443.9	448.4	440.8
Ca		354.0	346.9	354.6	352.1	365.1
Zn		40.04 abc	38.51 bcd	39.71 abc	39.57 a-d	38.14 cd
Fe		36.34	35.63	37.10	36.17	35.33
Mn		26.14	23.23	24.07	22.96	23.54
Cu		5.00	5.01	5.03	5.13	5.08
Na		4.87 d	4.95 c	4.89 d	4.89 d	4.87 d
		1	**2**	**3**	**4**	**5**
K	**2014-2015**	3358	3342	3689	3617	3492
P		1900 bc	1887 bc	1987 bc	1962 bc	1909 bc
S		1562 ab	1229 c	1187 c	1640 a	1495 ab
Mg		412.7	438.6	454.6	467.0	446.0
Ca		384.2	381.2	377.4	346.4	381.2
Zn		40.78 a	40.25 ab	37.61 d	41.45 a	38.57 bcd
Fe		35.10	36.96	38.09	36.16	36.13
Mn		22.78	24.47	25.22	21.46	22.38
Cu		4.88	5.10	5.02	5.25	4.89
Na		5.01 bc	5.03 b	5.04 b	5.11 a	5.04 b

* Values in each column showed by the same letter are not different according to LSD test at 5 % of significance level

Table 9. Changes of bran mineral content in bread wheat genotypes according to the interaction of growth condition×genotype (mg kg^{-1})

Minerals		**Genotypes**				
		1	**2**	**3**	**4**	**5**
K	**Organic conditions**	3460	3601	3629	3586	3342
P		2081 a*	1915 a-d	1775 d	2059 a	2003 abc
S		1491	1154	1174	1345	1292
Mg		409.6 d	440.6 bc	446.4 bc	448.8 abc	455.3 ab
Ca		366.5 ab	356.3 bc	362.0 bc	355.5 abc	386.6 ab
Zn		39.98	40.00	39.56	39.80	37.74
Fe		34.66 e	35.28 de	37.87 a	35.32 cde	36.32 bcd
Mn		23.96	22.94	24.76	21.64	23.45
Cu		4.97	5.10	4.94	5.12	5.01
Na		4.90 cd	5.03 a	4.99 ab	4.97 ab	4.89 d
		1	**2**	**3**	**4**	**5**
K	**Conventional conditions**	3326	3311	3582	3511	3510
P		1849 bcd	1954 a-d	2015ab	2101 a	1806 cd
S		1459	1450	1377	1678	1648
Mg		431.2 c	445.1 bc	452.1 ab	466.5 a	431.5 c
Ca		371.8 ab	371.8 ab	369.9 ab	343.0 c	359.7 bc
Zn		40.84	38.76	37.76	41.22	38.98
Fe		36.77 abc	37.32 ab	37.33 ab	37.00 ab	35.14 de
Mn		24.96	24.76	24.53	22.79	22.47
Cu		4.91	5.00	5.10	5.26	4.95
Na		4.98 ab	4.95 bc	4.94 bcd	5.03 a	5.02 a

* Values in each column showed by the same letter are not different according to LSD test at 5 % of significance level.

Table 10. Changes of bran mineral content in bread wheat genotypes according to the interaction of year×growth condition×genotype (mg kg^{-1})

Minerals	Genotip	2013-2014		2014-2015	
		Organic	Conventional	Organic	Conventional
S	1	1111 hi	1663 a-d	1870 a	1255 f-i
	2	1141 hi	1610 a-e	1167 hi	1291 f-i
	3	1329 e-h	1398 d-h	1018 i	1356 e-h
	4	1212 ghi	1553 b-f	1477 c-g	1804 ab
	5	1353 e-h	1536 b-f	1231 ghi	1759 abc
Mg	1	410.1 fg	446.1 a-d	409.1 g	416.2 efg
	2	453.8 abc	440.6b-e	427.4 c-g	449.7 abc
	3	445.7 a-d	442.1b-e	447.1 a-d	462.1 ab
	4	435.9 b-g	460.8ab	461.7 ab	472.3 a
	5	437.8 b-f	443.9b-e	472.8 a	419.2 d-g
Ca	1	347.3 cde	360.8 bcd	385.7 ab	382.7 ab
	2	327.8 e	366.1 a-d	384.9 ab	377.6 ab
	3	346.8 cde	362.4 a-d	377.3 ab	377.5 ab
	4	366.6 abc	337.6 de	344.5 cde	348.3 cde
	5	391.0 a	339.2 cde	382.2 ab	380.3 ab
Zn	1	39.58 b-h	40.50 a-e	40.39 a-f	41.18 abc
	2	40.27 a-g	36.75 h	39.73 b-g	40.78 a-d
	3	41.33 ab	38.10 d-h	37.79 e-h	37.43 gh
	4	36.80 h	42.35 ab	42.80 a	40.10 a-g
	5	37.94 d-h	38.35 c-h	37.53 fgh	39.61 b-h
Na	1	4.78 h	4.97 cde	5.02 bc	4.99 cd
	2	4.94 def	4.97 cde	5.12 a	4.93 def
	3	4.87 fg	4.91 ef	5.12 a	4.97 cde
	4	4.86 fgh	4.92 def	5.09 ab	5.14 a
	5	4.80 gh	4.94 def	4.98 cde	5.11 a

* Values in each column showed by the same letter are not different according to LSD test at 5 % of significance level

Table 11. Correlation coefficients (r) among the bran minerals of the bread wheat genotypes under organic and conventional conditions (n=30)

	K	P	S	Mg	Ca	Zn	Fe	Mn	Cu
P [§]	**-0.133** 0.057								
S	**-0.108** 0.130	**-0.217** -0.010							
Mg	**0.310** 0.340	**-0.379*** 0.549**	**-0.113** 0.135						
Ca	**-0.295** -0.133	**0.140** -0.182	**0.005** -0.318	**-0.073** -0.257					
Zn	**0.352** 0.082	**-0.279** 0.086	**0.296** -0.209	**-0.092** 0.251	**-0.514**** 0.092				
Fe	**0.039** -0.468**	**-0.035** 0.255	**-0.371*** 0.195	**0.132** 0.336	**0.344** 0.061	**-0.454*** -0.193			
Mn	**0.190** -0.239	**-0.144** 0.286	**-0.299** -0.287	**-0.103** 0.290	**0.166** -0.142	**-0.328** 0.068	**0.380*** 0.295		
Cu	**-0.248** 0.288	**-0.003** -0.044	**0.021** 0.080	**-0.141** 0.133	**-0.109** -0.059	**0.326** 0.032	**-0.110** -0.128	**0.060** -0.299	
Na	**0.508**** -0.034	**-0.212** -0.222	**0.166** 0.446*	**0.144** -0.106	**0.131** -0.010	**0.247** 0.056	**0.338** -0.263	**-0.091** -0.325	**0.122** 0.026

§ In the same line, the upper values in bold indicate the coefficients in organic conditions and the lower values in conventional conditions. *, ** show the significance levels at the probability of *P*<0.05 and *P*<0.01, respectively.

Relationships between Bran Minerals of the Bread Wheat Genotypes

Correlation coefficients of the bran mineral contents of the bread wheat genotypes under organic and conventional conditions were given in Table 11. Thus, there was a negative significant correlation (r=-0.379, *P*<0.01) between Mg and P under organic growth conditions while there was a positive significant correlation (r=0.549, *P*<0.01) between them under conventional conditions. Zn and Ca were negatively significantly correlated each other (r=-0.514, *P*<0.01). Fe was negatively significantly correlated with K (r=-0.468, *P*<0.01) under conventional conditions while it was negatively correlated with S (r=-0.371, *P*<0.05) under organic conditions. There was also negative significant correlation between Fe and Zn (r=-0.454, *P*<0.05) under organic growth conditions. Mn and Fe showed positive significant correlation (r=0.380, *P*<0.05) under organic conditions. Na presented positive significant correlations with K (r=0.508, *P*<0.01) under organic conditions, and with S (r=0.446, *P*<0.05) under conventional conditions.

Conclusion

Like all cereal products; bran, which is a fraction of grain, does not make sense by itself and its source is important. In other words, the conditions in which these genotypes are grown (including the growth seasons and growth conditions) have an effect on the nutritional contents of wheat bran, especially the genotype from which bran is obtained; in this study, it was concluded that bran minerals are significantly affected by these variation sources and their interactions, so that genotype and growth conditions should be considered in bran studies, and even location studies should be added to these factors.

Compliance with Ethical Standards

Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contribution

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

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